Futures 109 (2019) 63–72

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

# Envisioning future travel: Moving from high to low carbon systems

Jean Fletcher[a,*], Nancy Longnecker[a], James Higham[b,c]

[a] Department of Science Communication, University of Otago, Dunedin, New Zealand
[b] Department of Tourism, University of Otago, Dunedin, New Zealand
[c] Norwegian School of Hotel Management, University of Stavanger, Norway

ARTICLE INFO

*Keywords:*
Future travel
2050
Visions
Low carbon mobility
Climate change
Avoid-shift-improve

ABSTRACT

Comprehensive measures for reducing transport emissions were absent from the 2015 Paris Agreement yet without radical transformations in mobility systems and travel behaviour, transport emissions will continue to grow rapidly. This study investigated perceptions of travel in the year 2050 to see whether expectations of future travel align with lower carbon mobility systems. Data were collected through an international, online survey in 2016, targeting young adults with high levels of climate change concern. Thematic content analysis of responses (N = 401) revealed that 48% (n = 192) of participants described travel in 2050 as using low carbon mobility systems. This transition was predominantly attributed to improved technology (26%), rather than a shift in transportation mode (17%) or trip avoidance (12%). Expectations of future travel that could perpetuate high carbon mobility systems were mentioned by 53% (n = 212) of participants while only 23% (n = 94) mentioned factors that could reinforce low carbon mobility systems. These results show that even amongst people with high levels of concern about climate change, anticipated travel patterns have the potential to lock in high carbon transport and undermine progress. To achieve low carbon mobility transitions, strong international commitment must be supported by coordinated efforts of both governments and individuals.

## 1. Introduction

Climate change threatens significant and irreversible harm to ecosystems and society (Intergovernmental Panel on Climate Change [IPCC], 2014). To minimise future damage caused by climate change, the international community pledged to actively engage in climate change mitigation (United Nations [UN], 2015). Mobility is one area that requires rapid, large scale behavioural and systemic changes if climate change mitigation targets are to be met (IPCC, 2018; Sims et al., 2014); in 2010, 23% of all global greenhouse gas emissions were attributed to the transport sector (Sims et al., 2014). Unfortunately, transport remains contested within climate change mitigation as neither the aviation, nor maritime shipping industries were directly addressed by the Paris Agreement (Scott, Hall, & Gössling, 2016).

Increasingly, the transport and tourism literature has explored ways to facilitate the transition to low carbon mobility (e.g. Hopkins & Higham, 2016). This intersects with Futures research in the form of scenario building (e.g. Owen, Lee, & Lim, 2010; Yang, McCollum, McCarthy, & Leighty, 2009), visions, and backcasting (e.g. Ceron & Dubois, 2007; Tuominen, Tapio, Varho, Järvi, & Banister, 2014). Visions combine information, such as the extrapolation of data, with the values embedded in imagined desirable (or

* Corresponding author at: Centre for Science Communication, Te Paepae Pūtaiao, University of Otago, Owheo Building, 133 Union St East, P.O. Box 56, Dunedin 9054, New Zealand.
*E-mail address:* jean.fletcher@postgrad.otago.ac.nz (J. Fletcher).

https://doi.org/10.1016/j.futures.2019.04.004
Received 29 September 2018; Received in revised form 9 March 2019; Accepted 4 April 2019
Available online 05 April 2019
0016-3287/ © 2019 Elsevier Ltd. All rights reserved.

non-desirable) futures (Tapio & Hietanen, 2002). Bergman, Schwanen, and Sovacool (2017) describe future visions and imaginaries as important tools for transitioning to low carbon mobility systems as they can help initiate and fund projects, create interest, attract resources, and even shape innovation pathways if they become collectively accepted.

Our paper contributes to the research on transitioning to low carbon mobility by investigating people's expectations of travel in the year 2050. We begin the paper by discussing some of the challenges involved in transitioning to low carbon mobility, before discussing why it is useful to explore the expectations of future travel in a cohort reporting high levels of concern about climate change. Next, we critically investigate whether participants expect future transport to move towards lower carbon systems or continue using high carbon transport systems. We go on to discuss potential trade-offs between participants' expectations of future travel with respect to reducing carbon emissions and how these challenges can be addressed at a governmental, societal and/or individual level. Lastly, we consider whether the expectation of commercial space travel is incompatible with the idea of a low carbon mobility future.

## 2. Reducing transport emissions

It is clear that transport and travel emissions must be reduced in order to meet climate change mitigation targets; however, it is less clear how this reduction will be achieved. Since the projected growth of the aviation and shipping industries has the potential to undermine global carbon reduction efforts, there is concern that policy makers are approaching climate change mitigation with a business-as-usual mind set (Scott et al., 2016). A business-as-usual approach to climate change mitigation maintains existing high carbon mobility systems instead of transitioning towards lower carbon mobility systems (e.g. New Zealand's government investments in major road developments over redeveloping rail systems; Hopkins & Higham, 2016). This could mean favouring less disruptive end-of-pipe mitigation solutions which focus on capturing or sequestering carbon emissions over creating new low carbon transportation systems that limit the emissions produced (Unruh, 2002). However, a business-as-usual approach will not keep global temperatures below the agreed upon 1.5 °C rise from pre-industrialized temperatures (IPCC, 2014; UN, 2015). This sets up a potential paradox between the need for reduced carbon emissions within the transport industry and the reality of lowering carbon emissions while operating within current high carbon mobility systems.

One approach to facilitating the transition to low carbon mobility is the ***Avoid/Shift/Improve*** framework (Fulton, Lah, & Cuenot, 2013). This tactic suggests ***avoiding*** carbon emitting activities, ***shifting*** to alternate modes of transportation that are less carbon intensive, and ***improving*** current modes of transport so that they become less carbon intensive (Fulton et al., 2013). To date, attention for mitigating transport emissions has mainly focused on ***improving*** eco-efficiency, such as creating more fuel-efficient engines or utilising alternative fuels (Newman, 2016). Yeh et al. (2017) noted the prominence of alternate fuels and eco-efficiency in transportation projections through to 2050 but stressed that to meet mitigation targets, electric vehicle uptake needs to overshoot current policy commitments.

Sustainable consumption involves a system-wide change in the way society engages and consumes transport (Hall, 2016). City design and urban planning can play a large role in encouraging people to ***shift*** to alternate travel modes or ***avoid*** travel altogether (Nakamura & Hayashi, 2013). This includes ***shifting*** away from private car use towards increased public transport and ***avoiding*** long, carbon intensive trips through walking cities and local travel (Hopkins & Higham, 2016).

There can be no doubt that transitioning away from the current high carbon mobility system will be difficult because of what Unruh (2000) calls the techno-institutional complex — when technology and institutions reinforce each other. Therefore, people find themselves locked into dominant systems not because there are no alternative technologies but because of other influencing factors such as government policy or social norms (Unruh, 2000). System lock-in also applies to the academic discussion surrounding transport mitigation and sustainability which can be constrained by the neo-liberal mentality many researchers operate within (Schwanen, Banister, & Anable, 2011). Bergman et al. (2017) argue that the neo-liberal mentality that assumes economic growth is linked to individual car use may explain why more documents envisioning the trajectory of future low carbon mobility in the UK were techno-optimistic. These documents predicted that electric vehicles would be the path to low carbon mobility, ignored research suggesting that peak car use has already been reached and overlooked the possibility that behavioural and cultural changes like car sharing may be a realistic method of decreasing carbon emissions (Bergman et al., 2017).

## 3. Understanding public expectations of future travel

Due to the complex nature of transitioning to low carbon mobility systems, it is important to include the opinions of multiple stakeholders including the public (Tuominen et al., 2014). Exploration of what the public thinks about the trajectory of travel provides insight into the types of transport policies that may or may not be supported. Burstein's 2003 review of 30 research papers published between 1980–2000 found that public opinion affected policy approximately 75% of the time, with that effect categorised as a 'substantial influence' about 35% of the time. The review also cautiously suggested that public opinion remained a significant influencer of policy even in the presence of special interest groups and political parties (Burstein, 2003). Similarly, a New Zealand study found that a lack of awareness or demand to take action and lack of perceived importance to the public were the most reported barriers to implementing climate change adaptation plans [K. Archie, personal communication, May 5, 2018].

Investigating expectations of future travel may also identify inconsistencies between public expectations of future travel and what is realistic in terms of low carbon emissions. A Finnish study found the idea that travel emissions in 2050 will be substantially reduced by "radical technological development (p. 49)" was absent from expert visions of future travel but present in the visions of Finnish high school students (Tuominen et al., 2014). This suggests that experts and non-experts may have different understandings and

expectations regarding the potential of technology to mitigate climate change. Peeters, Higham, Kutzner, Cohen, and Gössling (2016) reviewed how daily print media from 1994 to 2013 reported proposed technological solutions to reducing emission within the aviation industry and found that most of these solutions were impossible, impractical, had been abandoned by the industry, or their ability to reduce emissions had been overstated. The authors suggested that promises of technological solutions to mitigating emissions may perpetuate the myth of an environmentally sustainable aviation industry (Peeters et al., 2016). They argue the existence of these 'myths' likely influences the public's expectations of future travel and their willingness to engage in transitions to low carbon mobility systems (Peeters et al., 2016).

### 3.1. Examining an interested public

A main argument for transitioning to low carbon mobility revolves around the environment and mitigating climate change (Hopkins & Higham, 2016). Therefore, one might expect individuals who are concerned about climate change to be taking climate change into consideration when thinking about future travel. Unlike a general public, an interested or an attentive public is aware of science and technology (Burns, O'Connor, & Stocklmayer, 2003). Exploring the expectations of a cohort who are already interested in and concerned about climate change may help identify barriers to transitioning to low carbon mobility beyond simply a lack of awareness or concern about climate change. A public interested in climate change may also represent early adopters of low carbon mobility. Research suggest pro-environmental attitudes are a characteristic of early adopters of low carbon mobility (Plötz, Schneider, Globisch, & Dütschke, 2014; Shaheen, Zhang, Martin, & Guzman, 2011). For these reasons, we explored perceptions of future travel in a group that would be expected to be thinking of environmentally sustainable futures.

## 4. Visions of future travel

Two studies exploring visions of future travel are Tight et al. (2011) and Tuominen et al. (2014). Tight et al. (2011) examined how three visions for the year 2030 could influence walking, cycling, public transportation usage and driving in urban areas in the UK: i) implementing best practises to encourage walking and cycling, ii) a shift in societal values, and iii) a severe constraint on fossil fuels. Our study is more similar to that of Tuominen et al.ös (2014) as it asked participants to describe what they believed the year 2050 would look like without providing specific contexts. Tuominen et al.ös (2014) study reported eight visions of what transport could look like in Finland in the year 2050, including a business-as-usual approach with little emissions reduction, relying on radical technology, and compact cities with increased use of public transport. While these two papers illustrated what the future travel might look like, our paper focuses on how specific expectations of future travel align or conflict with the idea of a low carbon future.

### 4.1. The year 2050

The year 2050 was selected as a focal point to represent the future. The year 2050 is often used by the IPCC in both their future scenarios and targets (IPCC, 2014). It is far enough away to allow for significant changes in technology, governmental policy and social norms, which is important because government and societies adapt more slowly than technology (Unruh, 2000). The year 2050 is also near enough to fall within the lifetimes of participants, potentially increasing its perceived relevance (Frittaion, Duinker, & Grant, 2010).

## 5. Methodology and methods

### 5.1. Survey design

This study was designed to explore individuals' perceptions of future transport systems. An online survey was used to collect primarily qualitative data with supporting quantitative data (Fletcher, 2018). Because the research was exploratory, we used an open-ended question when asking participants to describe their subjective expectations of travel in the year 2050. We did not want to restrict participants' answers regarding expectations of future travel into predetermined categories that may not be reflective of their beliefs (Braun & Clarke, 2006; Johnson & Onwuegbuzie, 2004). To avoid priming participants to think about future travel with respect to climate change, a question regarding climate change came after participants had been asked to describe their expectations of future travel. Multiple choice and Likert scale questions were used to collect quantitative data regarding participant demographics, and levels of climate change concern. Demographic information collected included participant age, gender, nationality and level of education.

### 5.2. Data collection

Data were collected through an internet-based survey hosted by SurveyGizmo™ which ran from February 24$^{th}$ to May 5$^{th}$, 2016. An online survey was used because it was inexpensive, had the potential for global reach and was convenient for both researchers and participants (Evans & Mathur, 2005). A total of 401 useable responses were collected. Surveys were excluded if participants stopped answering questions part way through, as early termination was taken as a withdrawal of consent. As an incentive to increase participation and completion rate, participants were offered the chance to enter a draw for a $100 US Amazon gift card. Following the survey, a winner was selected using a random number generator. The research was approved by the University of Otago's Human

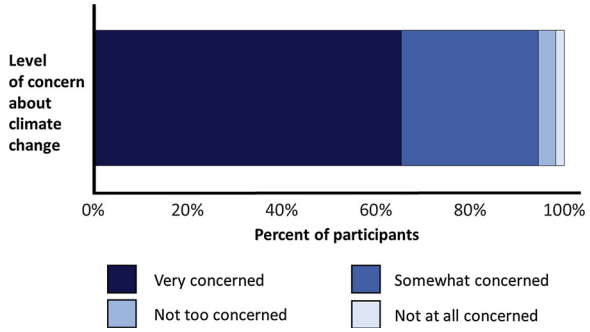


**Fig. 1.** Participants' reported level of concern about climate change (N = 399).

Research ethics committee (Ref: D15/393) and all participants gave informed consent before proceeding into the survey.

#### 5.2.1. Sampling procedure

The sampling procedure targeted participants who would be expected to be thinking about low carbon mobility futures and/or exhibit characteristics of low carbon adopters. Being young and highly educated are characteristics associated with early adopters (Rogers, 2010) and pro-environmental attitudes are specifically associated with early adoption of low carbon mobility (Plötz et al., 2014; Shaheen et al., 2011). Convenience sampling was used as a cost-effective method of eliciting responses (Marshall, 1996). Links to the online survey were publicly posted and shared on Facebook™ and Twitter™. These platforms allowed for snowball sampling (Noy, 2008) where people reached by initial posts could share or retweet the research invitation to others within their own networks. Recruitment targeted young adults aged 18–35 who would be 52–68 years old in 2050 and would likely still be travelling at this time; respondents over the age of 35 were not excluded from the study. Recruitment notices were placed to attract younger adults who may be interested in travel. Survey links were posted on two backpacker forums (one international and one New Zealand specific). Physical flyers containing the hyperlink and a quick response (QR) code that linked directly to the survey were posted at four backpackers' hostels in *Dunedin*, a popular tourist town on the South Island of New Zealand.

Email invitations to participate were sent to all departments at the *University of Otago*, two mailing lists associated with the first author's department, an international science communication mailing list, a Canadian university's science communication department, an Australian university's science communication department and an Australian science communication mailing list. Tramping, travelling or cycling clubs at institutions throughout New Zealand were also targeted and sent an email request to participate in the research.

#### 5.2.2. Participants

As expected, participants reported a high level of climate change concern (Fig. 1). The majority 65% (n = 263) of the 401 participants stated that they were 'very concerned

about climate change'. New Zealanders were the most represented (39%) nationality within this study, followed by Australians (13%), Canadians (12%) and Americans (10%; Fig. 2a). Of the 395 respondents who provided their age, 61% were within the target age group of 18–35 (Fig. 2b). The majority (68%) of participants in the study were female (Fig. 2c). This may be significant for this study as females tend to be more concerned about climate change than males (McCright, 2010). Participants also tended to be highly educated, with 95% having a tertiary education and 55% having obtained some type of postgraduate qualification (Fig. 2d).

### 5.3. Data analysis

Qualitative data were analysed using thematic and content analysis. Thematic coding is a qualitative research method that identifies key concepts or 'themes' (Braun & Clarke, 2006) and content analysis allows others to replicate these themes (Krippendorff, 2012). A coding manual for responses about perceptions of travel in 2050 (Appendix A) was developed and was used in a number of iterative coding rounds between two of the authors, and another member of the first author's research group. Each iteration involved coding a sample of 20–40 responses (5–10% of the data), followed by robust discussions where codes were merged, dropped, added, or refined until the researchers agreed upon four overarching themes (Appendix A). Intercoder reliability was calculated and percent agreement between the three researchers ranged from 87%–100%. Krippendorff α was calculated with 'changes in travel that could reinforce low carbon transport systems' having the lowest score at 0.681. The high level of agreement between the researchers supports our assertion that the analysis of the data is reliable (Krippendorff, 2012). Minor spelling and grammatical errors were corrected when reporting participants' typed descriptions of future travel. Quantitative data were analysed using descriptive statistics in SPSS™ version 24.

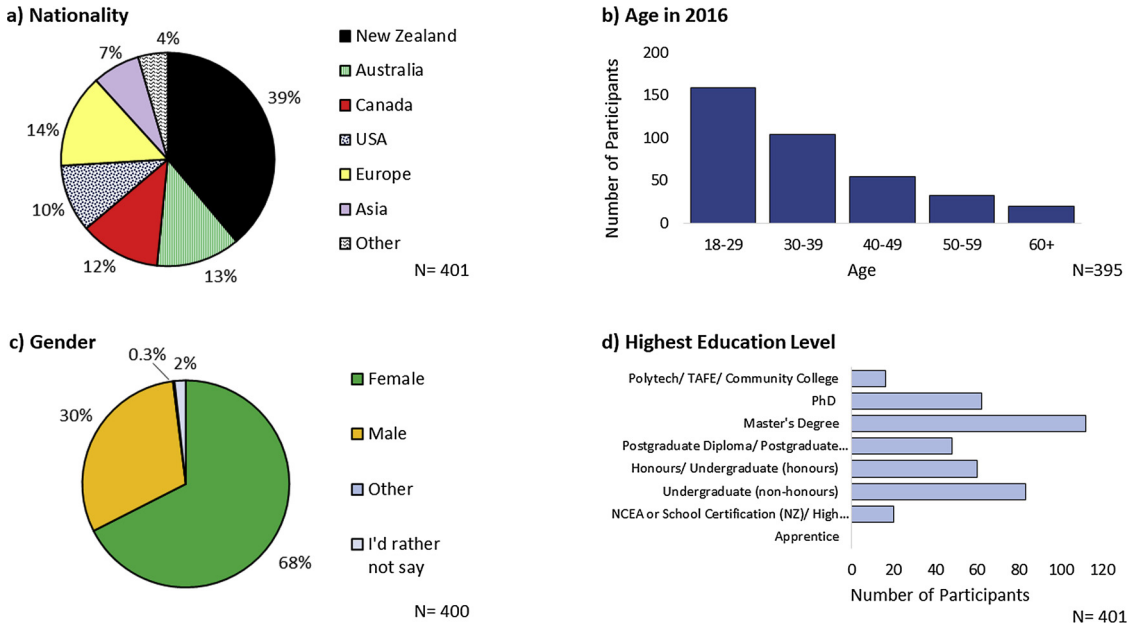


**Fig. 2.** Nationality (a), age (b), gender (c) and education level (d) of respondents.

## 6. Results and discussion

### 6.1. Expectations of travel in 2050

When asked if travel would be different in the year 2050, 91% (n = 365) of participants agreed. Just under half (48%, n = 192) of the participants described travel as having transitioned to low carbon mobility even though 66% of participants stated that they were very concerned about climate change (Fig. 1). This suggests that low carbon mobility and environmental sustainability may not be top of mind when thinking about future travel. However, participants who reported higher levels of climate change concern were still significantly more likely to describe future travel as involving low carbon mobility ($r(399) = 0.114$, $p = 0.023$) suggesting that expectations of future travel are related to levels of climate change concern.

Grouping participants' depictions of lower carbon mobility using the categories of ***Avoid/Shift/Improve*** revealed that the most commonly mentioned approach to reducing carbon emissions was via technological advancements such as using less fossil fuels through improved engines or switching to alternative fuels (Tables 1; see *Appendix A* for full coding details).

> I imagine we will not be dependent on fossil fuels and will primarily use renewable or sustainable fuel sources. With this will come new technological advances such as better electric cars or even hydrogen cars and other better transportation vehicles. [Female, American, 30–39]

Participants discussed shifting to alternate modes of transport including increased use of mass transport, cycling and walking (Table 1).

> If we have a crisis of conscience about carbon footprint and modes of travel don't change hugely, then we will walk or revert to bicycles and horses/donkeys. [Female, New Zealander, 50–59]

Avoiding travel was the least frequently discussed approach to reducing carbon emissions. Participants wrote about there being less flying, more local travel, less physical travel and more virtual travel (Table 1). For instance:

> People will travel less. They will commute shorter distances and do so much less driving cars. They will also fly less due to cost. There will be an important shared transportation infrastructure. [Male, Swiss, 30–39]

**Table 1**
Participants' descriptions of low carbon mobility with respect to the Avoid/Shift/Improve transitional approach (N = 401).

| Approach | Frequency | Percent |
|---|---|---|
| Improve | 106 | 26 |
| Shift | 70 | 17 |
| Avoid | 48 | 12 |

There were also general references to travel becoming more environmentally sustainable (i.e. cleaner, greener and more eco-friendly; n = 38, 9%). For example, “Technology is always increasing and improving so [it is] likely [there will be] faster, cleaner means of transport [Female, French, 40–49].”

These results show that participants primarily think of ***improved*** eco-efficiency and alternate fuels as the path towards a low carbon future. While ***improved*** technology may decrease carbon emissions this reduction could be undercut by an increase in travel as this approach does not reduce travel demand (Nakamura & Hayashi, 2013). Additionally, meeting climate change mitigation targets by relying on ***improvements*** to current technology requires earlier or more widespread adoption than would ***shifting*** or ***avoiding*** travel (Fulton et al., 2013). Therefore, the longer it takes to create or adopt lower carbon technology, the less likely successful mitigation becomes using this strategy. This is complicated by the fact that rapid adoption of electric vehicles could be bottlenecked by cobalt shortages (currently used in electric vehicle batteries; Olivetti, Ceder, Gaustad, & Fu, 2017).

Only 23% (n = 91) of participants described travel in 2050 in a way that suggested continued use of high carbon mobility systems. These responses referred to the continued use of cars and airplanes without suggesting any attempts to lower the carbon output. This included statements such as “Catching a plane will be like catching a bus [Female, New Zealander, 18–29].”

While participants’ depictions of travel in 2050 were almost evenly split between maintaining current high carbon systems and having transitioned to lower carbon mobility systems (53% vs. 48%), they were more likely to mention expectations that would reinforce high carbon mobility than they were to mention expectations that would reinforce a transition to low carbon mobility (55% vs 23%). Travel becoming cheaper or more convenient, individuals travelling further, an increased number of people travelling and/or people travelling more often were expectations that have the potential to reinforce current high carbon mobility systems by encouraging more travel. Other expectations that could reinforce high carbon transport systems included the notion that by 2050 travel will be faster and involve commercial space travel (Table 2; See next section for further discussion).

> I think that travelling in 2050 will be much simpler and more common. There will be increased availability and faster modes of transportation available, which will increase convenience and lower costs. I think it will be commonplace to go from Canada to Europe for vacations or even farther away, like Asia or the Middle East. [Female, Canadian, 18–29]

Participants discussed future travel in a way that could reinforce a shift towards lower carbon mobility systems. These expectations included factors that could discourage travel such as increased expenses, inconvenience, safety concerns, and restrictions. The notion that travel will become slower was extremely uncommon (Table 2).

> I also wonder whether the number of people who can travel, where we will have the right to go or where we may no longer want to go will change. Wars, climate change, different combinations of visas and country agreements or disagreements might make currently "normal" destinations seem impossible to travel to. [Female, United Kingdom, 30–39]

## 7. The cost of travel: potential trade-offs between time, convenience, monetary expense and low carbon mobility

The previous section identified participants’ expectations regarding travel in the year 2050. We found that although 48% of respondents described forms of lower carbon mobility, 55% mentioned expectations that could reinforce high carbon mobility systems. This suggests that participants may have conflicting desires when it comes to future travel. These reinforcing expectations highlight the fact that there are costs to transitioning to low carbon mobility systems as well as costs to continuing to utilise high carbon mobility systems. Three potential costs that will be explored in this section are time, convenience and monetary expense.

### *7.1. Time*

The fact that 41% of participants expected travel to become faster (some even suggested it would be instantaneous) while only 1% discussed travel becoming slower highlights the importance respondents placed on time. Yet, valuing time may have unintended negative consequences upon people’s willingness to ***shift*** to other forms of transportation that produce less carbon emissions but are slower. Consider participants’ expectations regarding the future of aeromobility. Very few participants suggested that there will be less flying in 2050 even though air travel conflicts with the idea of low carbon transport (Scott et al., 2016). A common explanation for why people choose to fly is because it is faster than other mass transport such as trains (Hares, Dickinson, & Wilkes, 2010; Miller, Rathouse, Scarles, Holmes, & Tribe, 2010). Participants may assume flying will continue being a common mode of transportation in

**Table 2**
Factors in participant descriptions of future travel that could reinforce low or high carbon travel in 2050 (N = 401).

| Transport System | Reinforcing Factors | Frequency | Percent |
|---|---|---|---|
| High carbon transport systems | Faster travel | 157 | 39 |
| | Factors encouraging travel | 121 | 30 |
| | Space travel | 31 | 8 |
| Low carbon transport systems | Factors discouraging travel | 91 | 23 |
| | Slower travel | 5 | 1 |

the future based on their expectation that future travel will be faster and flying is the fastest form of travel currently available. One participant explained "Travel will still be done predominantly by air travel as it balances speed with the efficiency of high altitude. However, aircraft will be much more efficient [Male, New Zealander, 18–29]."

The above quote illustrates the prevalent assumption amongst participants that industry and technology would advance so that individuals could engage in lower carbon mobility without sacrificing speed. Another respondent wrote, "I think [future travel] will be easier in terms of speed and comfort as technology develops and it will become more environmentally conscious [Female, New Zealander, 18–29]. This assumption that technology can accommodate multiple priorities could explain why participants who described elements of a lower carbon future most often talked about technological solutions such as alternate fuels and ***improved*** fuel efficiency instead of ***shifting*** to other modes of transport or ***avoiding*** travel (Table 1).

Given the importance of speed to our participants, it appears that the 'slow travel' movement which has been explored as being a more climate friendly method of travel (Ceron & Dubois, 2007; Dickinson, Lumsdon, & Robbins, 2011) is an unrealistic way to facilitate a transition towards a low carbon mobility system because the majority of people expect travel to be fast. Perhaps a better avenue of transition would involve aligning low carbon alternatives such as public transport with participants' expectations of speed. It was suggested that high speed rail would become more prevalent by 2050. There is a possibility that high speed train networks could make rail travel more appealing, thus ***shifting*** passengers away from air travel but it is difficult to know whether these trains will be fast enough to compete with airplanes.

To help encourage people to ***shift*** to alternate lower carbon modes of transportation like public transport, structural changes including changes in government funding, policies and regulations could be enacted to address infrastructure. For example, public transport users in Portugal stated that the presence of bus lanes on highways meant that public transport could be faster than private vehicles, increasing its appeal (Beirão & Cabral, 2007). In terms of individual practices, simply getting people to try public transport can positively influence their perceptions regarding its speed (Fujii, Gärling, & Kitamura, 2001). If individuals realise that public transport is not as slow as they previously thought they may be more likely to utilise the service. This may be an important step as habits can facilitate public transport use (Bamberg, Ajzen, & Schmidt, 2003).

### 7.2. Convenience

Along with the expectation that future travel would become faster, it was also stated that future travel would become more convenient. For example, "I think travelling in 2050 will be faster, more convenient, and more common [Female, Canadian, 18–29]." One reason ***improving*** technology to increase its eco-efficiency may have been so popular amongst participants could be because it aligned with their expectations of convenience. Swapping to an electric car allows a person to be more environmentally friendly without giving up the convenience of having their own vehicle, whereas public transport can be perceived as being inconvenient due to many factors including lack of infrastructure, problems with punctuality, and longer length of trips (Beirão & Cabral, 2007; Khalid, Bachok, Osman, & Ibrahim, 2014).

Studies investigating how to get more people to cycle instead of drive have found that conveniences such as the presence of bike paths and bike lanes (Buehler & Pucher, 2012), traffic lights, intersections (route connectivity), lack of highway or hills and shorter distances increased the likelihood that people will cycle (Winters, Brauer, Setton, & Teschke, 2010). If transitioning towards low carbon mobility conflicts with the expectation of increased convenience, then people may be conflicted about engaging in this transition.

To address this, governments can create infrastructure to increase the convenience of low carbon mobility options. One participant envisioned "The railway network will be improved [making it easier] to travel to other cities which are far away [Female, Hong Kong, 18–29]." Not only could improved infrastructure address convenience at a structural level, it may also work at a cultural level by helping to reinforce social norms. While a 2013 review of the global literature on bike share programs found that people were unlikely to give up driving to start cycling (Fishman, Washington, & Haworth, 2014), Harré (2011) suggests that observing other people cycle to work might lead to changes in individual travel behaviour through the processes of modelling and social norms. Therefore, by making cycling more visible bike share programs may help individuals ***shift*** from using public transport to bicycling (Fishman et al., 2014).

### 7.3. Monetary cost

There was also the expectation that future travel would become less expensive. For example, "Travel is always becoming faster, more efficient, cheaper, and more economic [Female, New Zealander, 18–29]." This included the idea that "flying will be much cheaper [Female, Japanese, 18–29]" in 2050. Participants' expectations (or hopes) that airlines will continue to reduce their prices could lead to i) the continuation of travel by airplane, ii) an increased number of people flying because they can afford it, and/or iii) people flying more often. Since flying is a significant contributor to carbon emission (Scott et al., 2016), scenarios that predict an increased number of flights are scenarios where high carbon mobility is perpetuated, again suggesting that expectations of future travel may conflict with realistic transitions to low carbon mobility systems.

To align the idea of increased air travel with the notion of lower carbon mobility some participants predicted that there would be "hydrogen powered airplanes [Male, American, 40–49]" or "that flight may use biofuels, or some technology that has yet to be invented [Male, New Zealander, 30–39]." However, Åkerman (2005) argues that while large scale design changes may be most effective at lowering GHG emissions within the aviation industries, they are less likely to be actualised by 2050 compared to smaller incremental improvements. Therefore, while participants may expect new technology to help mitigate climate change this may be

unrealistic. Unfortunately, even small gains in efficiency within the aviation industry are expected to be overshadowed by an increased number of people flying. This highlights the downside of relying too heavily on radical technological changes to facilitate the transition to low carbon mobility.

The few participants who suggested that there would be less flying in the year 2050 often attributed this change to an increase in monetary cost. One participant wrote, "I don't think there will be as much travel by plane because of the cost of fuel and environmental concerns [Female, Australian, 50–59]." The term 'prohibitively expensive' was used amongst respondents and illustrates the view that cost can dictate people's mode of transport. The relatively cheaper price of airplane tickets compared to train tickets in Europe has been identified as an influencing factor as to why people choose air over rail travel (Hares et al., 2010; Miller et al., 2010). Thus, monetary incentives could be a way to encourage individuals to ***avoid*** or ***shift*** away from high carbon mobility.

Government policies that could encourage people to engage in more sustainable travel include adding an estimation of cost for environmental damage to the cost of the transport option (Sumner, Bird, & Dobos, 2011). However, monetary cost is not the only factor and possibly not the main factor in transport decision-making as illustrated by the simple fact that most people are not cycling to work despite the fact that bicycles are significantly less expensive than cars. Additionally, encouraging people to adopt more sustainable methods of travel by taxing or increasing the cost of transport that uses fossil fuel could exacerbate inequity. A 2007 review of sustainable transport suggested that road taxes could unfairly punish poorer families who are less able to afford to pay the tax yet may be more reliant on cars to complete daily errands such as dropping children off at school (Chapman, 2007).

This idea of exacerbated inequality was mentioned by a small number of participants (n = 8) who alluded to the fact that if flying becomes more expensive in the future then only a privileged few will be able to continue to afford to fly while everyone else will either have to travel less or travel differently.

> I think there will be two modes of travel. The very wealthy will have access to technology that permits fast and convenient reaching of any destination, including off planet and there will be bespoke activities for these to engage in. The remainder of the population will travel more locally and will travel less frequently because it will be too expensive. They will largely travel online and in virtual mode. [Female, German, 50–59]

Research on social tourism suggests that low income families benefit from having the opportunity to travel, so policies that use cost as a travel deterrent could negatively impact low income families (Minnaert, Maitland, & Miller, 2009). However, these reported benefits were achieved with local holidays which would align with lower carbon mobility systems (Minnaert et al., 2009).

## 8. The incompatibility of commercial space travel and low carbon mobility

One popular expectation that may be incompatible with reducing carbon emissions is the idea of commercial space travel. Commercial space travel included references to both space tourism and faster transportation via sub-orbital space travel.

> I imagine by 2050 space tourism will also have taken off, and it will be more accessible for average people to travel to space (maybe the moon!) [Female, New Zealander, 18–29]

However, there are questions surrounding the possibility of transition to a lower carbon mobility system by the year 2050 while engaging in commercial space travel. Considerations as to whether commercial space travel is beneficial or harmful to sustainability include whether sustainability extends beyond earth (Spector, Higham, & Doering, 2017), the implications of mining space resources (Newman, 2015), build-up of debris in space (Durrieu & Nelson, 2013), and the ability to inspire stewardship (Spector et al., 2017). There does not appear to be any literature suggesting space tourism will reduce carbon emissions. In fact, Ross, Mills, and Toohey, (2010) suggested that commercial space travel could end up significantly contributing to climate change. Their findings were based on models of black carbon particulates that are emitted by the engines expected to be used in many suborbital aircrafts (Ross et al., 2010). Thus, even if commercial space travel is beneficial to sustainability it may still be inconsistent with the transition to lower carbon mobility.

## 9. Conclusion

This study explored expectations of travel in the year 2050 of a cohort who reported high levels of concern about climate change and therefore would be presumed to be thinking about low carbon futures. We found 48% of participants expected future travel to become more environmentally sustainable. At the same time, 55% of participants described expectations that could perpetuate current high carbon systems (e.g. travel will become cheaper, faster, and more convenient) setting up a paradox between what people expect future transport technology to achieve and what may be realistic.

Our findings suggest that even climate concerned individuals are not necessarily thinking about low carbon mobility futures and that individuals may need to re-evaluate their priorities and determine what sacrifices are acceptable. Governments need to realize that even people who are very concerned about climate change do not automatically expect future travel to transition towards low carbon mobility. Therefore, simply making people more aware about climate change is not a useful method of inspiring the transition to low carbon mobility lifestyles. Policies aimed at facilitating behaviour change to low carbon mobility may be more effective when they align with other values such as speed, convenience and cost. It is important for people to understand that there are downsides to relying too heavily on game changing technology and that the transition to low carbon mobility will need to occur through cultural and behavioural change using the technology and resources currently available.

This research found that people have conflicting expectations of future travel. Future research could look at whether exposure to

different visions of future travel can change people's expectations of future travel to make them more consistent with the idea of low carbon mobility. Research could also investigate the relationship between people's expectations of future travel and their willingness to engage in low carbon transportation now. A third option would be to explore more deeply the prevalence of technological optimism amongst the public and if and how that may become more realistic. Regardless of the competing expectations people hold, mitigating climate change requires a system wide transition to low carbon mobility systems that aligns with personal values and hence identities (Longnecker, 2016). To increase the chances that this transition occurs well before the year 2050, governments and individuals need to actively start changing now instead of expecting the transition to magically occur sometime in the distant future.

## Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Acknowledgements

We would like to thank all of the participants who provided responses and Andrea Liberatore for help with coding the results.

## References

Åkerman, J. (2005). Sustainable air transport—On track in 2050. *Transportation Research Part D: Transport and Environment, 10*(2), 111–126.
Fletcher, J. (2018). *Travelling towards 2050: Climate change, storytelling and the future of travel*(Unpublished doctoral thesis). University of Otago].
Bamberg, S., Ajzen, I., & Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action. *Basic and Applied Social Psychology, 25*(3), 175–187.
Beirão, G., & Cabral, J. S. (2007). Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy, 14*(6), 478–489.
Bergman, N., Schwanen, T., & Sovacool, B. K. (2017). Imagined people, behaviour and future mobility: Insights from visions of electric vehicles and car clubs in the United Kingdom. *Transport Policy, 59*, 165–173.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.
Buehler, R., & Pucher, J. (2012). Cycling to work in 90 large American cities: New evidence on the role of bike paths and lanes. *Transportation, 39*(2), 409–432.
Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: A contemporary definition. *Public Understanding of Science, 12*(2), 183–202.
Burstein, P. (2003). The impact of public opinion on public policy: A review and an agenda. *Political Research Quarterly, 56*(1), 29–40.
Ceron, J. P., & Dubois, G. (2007). Limits to tourism? A backcasting scenario for sustainable tourism mobility in 2050. *Tourism and Hospitality Planning & Development, 4*(3), 191–209.
Chapman, L. (2007). Transport and climate change: A review. *Journal of Transport Geography, 15*(5), 354–367.
Dickinson, J. E., Lumsdon, L. M., & Robbins, D. (2011). Slow travel: Issues for tourism and climate change. *Journal of Sustainable Tourism, 19*(3), 281–300.
Durrieu, S., & Nelson, R. F. (2013). Earth observation from space–The issue of environmental sustainability. *Space Policy, 29*(4), 238–250.
Evans, J. R., & Mathur, A. (2005). The value of online surveys. *Internet Research, 15*(2), 195–219.
Fishman, E., Washington, S., & Haworth, N. (2014). Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia. *Transportation Research Part D: Transport and Environment, 31*, 13–20.
Frittaion, C. M., Duinker, P. N., & Grant, J. L. (2010). Narratives of the future: Suspending disbelief in forest-sector scenarios. *Futures, 42*(10), 1156–1165.
Fujii, S., Gärling, T., & Kitamura, R. (2001). Changes in drivers' perceptions and use of public transport during a freeway closure. *Environment and Behavior, 33*(6), 796–808.
Fulton, L., Lah, O., & Cuenot, F. (2013). Transport pathways for light duty vehicles: Towards a 2° scenario. *Sustainability, 5*(5), 1863–1874.
Hall, C. M. (2016). The challengers of changing the paradigms, regimes and structures of low carbon mobility. In D. Hopkins, & J. Higham (Eds.). *Low carbon mobilitiy transitions*. Oxford: Goodfellow Publishers.
Hares, A., Dickinson, J., & Wilkes, K. (2010). Climate change and the air travel decisions of UK tourists. *Journal of Transport Geography, 18*(3), 466–473.
Harré, N. (2011). *Psychology for a better world: Strategies to inspire sustainability.* Retrieved fromhttp://psych.auckland.ac.nz/psychologyforabetterworld.
Transitioning to Low carbon mobility. In D. Hopkins, & J. Higham (Eds.). *Carbon mobility transitions* (pp. 1). Oxford: Goodfellow Publishers Ltd.
IPCC (2014). In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.). *Summary for policymakers. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 1–32). Cambridge, United Kingdom and New York, NY, USA: IPCC.
IPCC (2018). In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, C. Moufouma-Okia, R. Péan, S. Pidcock, J. B. R. Connors, Y. Matthews, X. Chen, M. I. Zhou, E. Gomis, M. Lonnoy, M. Tignor, & T. Waterfield (Eds.). *Summary for policymakers. Global warming of 1.5 °C. An IPCC Special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (pp. 32). Geneva: World Meteorological Organization.
Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14–26.
Khalid, U. A., Bachok, S., Osman, M. M., & Ibrahim, M. (2014). User perceptions of rail public transport services in Kuala Lumpur, Malaysia: KTM Komuter. *Procedia—Social and Behavioral Sciences, 153*, 566–573.
Krippendorff, K. (2012). *Content analysis: An introduction to its methodology* (3rd ed.). Thousand Oaks: Sage.
Longnecker, N. (2016). An integrated model of science communication – More than providing evidence. *Journal of Science Communication. 15*(05), 1–13.
Marshall, M. N. (1996). Sampling for qualitative research. *Family Practice, 13*(6), 522–526.
McCright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Population and Environment, 32*(1), 66–87.
Miller, G., Rathouse, K., Scarles, C., Holmes, K., & Tribe, J. (2010). Public understanding of sustainable tourism. *Annals of Tourism Research, 37*(3), 627–645.
Minnaert, L., Maitland, R., & Miller, G. (2009). Tourism and social policy: The value of social tourism. *Annals of Tourism Research, 36*(2), 316–334.
Nakamura, K., & Hayashi, Y. (2013). Strategies and instruments for low-carbon urban transport: An international review on trends and effects. *Transport Policy, 29*, 264–274.
Newman, C. J. (2015). Seeking tranquillity: Embedding sustainability in lunar exploration policy. *Space Policy, 33*, 29–37.
Newman, P. (2016). The underlying structures of low carbon mobility. In D. Hopkins, & J. Higham (Eds.). *Low carbon mobility transitions*. Oxford: Goodfellow Publishers Ltd.
Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. *International Journal of Social Research Methodology, 11*(4), 327–344.
Olivetti, E. A., Ceder, G., Gaustad, G. G., & Fu, X. (2017). Lithium-ion battery supply chain considerations: Analysis of potential bottlenecks in critical metals. *Joule, 1*(2), 229–243.
Owen, B., Lee, D. S., & Lim, L. (2010). Flying into the future: Aviation emissions scenarios to 2050. *Environmental Science & Technology, 44*(7), 2255–2260.
Peeters, P., Higham, J., Kutzner, D., Cohen, S., & Gössling, S. (2016). Are technology myths stalling aviation climate policy? *Transportation Research Part D: Transport*

*and Environment, 44*, 30–42.
Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A: Policy and Practice, 67*, 96–109.
Rogers, E. M. (2010). *Diffusion of innovations.* New York, NY: Simon and Schuster.
Ross, M., Mills, M., & Toohey, D. (2010). Potential climate impact of black carbon emitted by rockets. *Geophysical Research Letters, 37*(24).
Schwanen, T., Banister, D., & Anable, J. (2011). Scientific research about climate change mitigation in transport: A critical review. *Transportation Research Part A: Policy and Practice, 45*(10), 993–1006.
Scott, D., Hall, C. M., & Gössling, S. (2016). A report on the Paris Climate Change Agreement and its implications for tourism: Why we will always have Paris. *Journal of Sustainable Tourism,* 1–16.
Shaheen, S., Zhang, H., Martin, E., & Guzman, S. (2011). China's Hangzhou public bicycle: Understanding early adoption and behavioral response to bikesharing. *Transportation Research Record: Journal of the Transportation Research Board,* (2247), 33–41.
Sims, R., Schaeffer, R., Creutzig, F., Cruz-Núñez, X., D'Agosto, M., Dimitriu, D., ... Tiwari, G. (2014). Transport. In O. R. Edenhofer, E. F. Y. Pichs-Madruga, S. Sokona, K. Kadner, A. Seyboth, I. Adler, S. Baum, P. Brunner, B. Eickemeier, J. Kriemann, S. Savolainen, C. Schlömer, von Stechow, T. Zwickel, & J. C. Minx (Eds.). *Climate change 2014: Mitigation of climate change*Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press Contribution of working group iii to the fifth assessment report of the intergovernmental panel on climate change.
Spector, S., Higham, J. E., & Doering, A. (2017). Beyond the biosphere: Tourism, outer space, and sustainability. *Tourism Recreation Research,* 1–11.
Sumner, J., Bird, L., & Dobos, H. (2011). Carbon taxes: A review of experience and policy design considerations. *Climate Policy, 11*(2), 922–943.
Tapio, P., & Hietanen, O. (2002). Epistemology and public policy: Using a new typology to analyse the paradigm shift in Finnish transport futures studies. *Futures. 34*(7), 597–620.
Tight, M., Timms, P., Banister, D., Bowmaker, J., Copas, J., Day, A., ... Macmillen, J. (2011). Visions for a walking and cycling focussed urban transport system. *Journal of Transport Geography, 19*(6), 1580–1589.
Tuominen, A., Tapio, P., Varho, V., Järvi, T., & Banister, D. (2014). Pluralistic backcasting: Integrating multiple visions with policy packages for transport climate policy. *Futures, 60*, 41–58.
United Nations (2015). *United Nations treaty collection chapter XXVII environment, 7.d Paris Agreement, Paris, 12 December 2015 (C.N.92.201).* New York: United Nations.
Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy, 28*(12), 817–830.
Unruh, G. C. (2002). Escaping carbon lock-in. *Energy Policy, 30*(4), 317–325.
Winters, M., Brauer, M., Setton, E. M., & Teschke, K. (2010). Built environment influences on healthy transportation choices: Bicycling versus driving. *Journal of Urban Health, 87*(6), 969–993.
Yang, C., McCollum, D., McCarthy, R., & Leighty, W. (2009). Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California. *Transportation Research Part D: Transport and Environment, 14*(3), 147–156.
Yeh, S., Mishra, G. S., Fulton, L., Kyle, P., McCollum, D. L., Miller, J., ... Teter, J. (2017). Detailed assessment of global transport-energy models' structures and projections. *Transportation Research Part D: Transport and Environment, 55*, 294–309.